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ABSTRACT

Courses designed to teach problem-solving and creativity, which are relatively new additions to college curricula, are discussed, along with their intellectual foundations and research on these two processes. The teaching of these processes involves the following course goals: teaching a specific subject, generally useful skills, and professional skills. Problem-solving applications are considered first. A subject may be taught through use of a guided design approach, which involves following a series of steps that lead to a solution. Teaching generally useful skills focuses on a set of strategies and heuristics rather than on a series of specific steps to be followed. Programs attempt to help students become better thinkers. Teaching professional skills can be illustrated by a problem-based approach to medical education. Information, concepts, and skills learned by students are put into their memory in association with a problem. Creative learning and discovery experiences can be part of learning a subject. Usually, programs teaching creativity as a generally useful tool use heuristics (e.g., asking students to think like an inventor or encouraging them to reach a high level of abstract reasoning). Teaching specific skills for the development of creativity are found in both the sciences and the arts. (SW)

AAHE-ERIC HIGHER EDUCATION

Research Currents

Teaching Problem-Solving and Creativity in College Courses

by Neal Whitman

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Courses designed to teach problem-solving and creativity are relatively new additions to college curricula. Many courses attempt to incorporate these processes in the teaching of traditional subjects. The intellectual foundations for these courses are solid; and their development, implementation, and evaluation warrants continuous review.

Intellectual Foundations

Problem-solving and creativity are considered to be related processes of human cognition. Problem-solving is an activity which leads to the best value for an unknown (Woods et al. 1979, p. 277). The solution of a problem entails the best but not necessarily the sole answer, and usually encompasses both a strategy and elements of skill necessary to carry out that strategy.

Creativity is an activity that results in contributions to the intellectual sphere of human experience which have novelty and value (Wiesner 1975, p. 527). According to Woods (1977), creativity is the ability to think in alternatives. However, "creativity" is a highly subjective concept: while almost everyone agrees that Albert Einstein was a creative scientist and that Beethoven was a creative artist, there is a greater range of opinion regarding the work of less talented individuals, especially if they are contemporary.

While problem-solving is seen as a cognitive process, there is less accord regarding the nature of creativity. Some researchers (e.g. Bransford, 1979) see creativity mainly as a cognitive process, whereas others (e.g. Stein, 1974) see it as both a cognitive and a noncognitive process that includes motivational and attitudinal dimensions.

Although much research on the nature of these processes asks how humans think, the related question of how they learn is important, especially in training students to solve problems and become more creative. Many such programs use the learning theories of Dewey (1933) on inquiry, Piaget (1952) on states of cognitive development, and Newell and Simon (1972) on artificial intelligence. A valuable overview of both learning theory and research is provided by Mertz (1981).

Historical background. Although intellectual historians trace interest in the nature of "thinking" to ancient Greek philosophy, inquiry on how humans think is relatively new as a *science.* The field of cognitive science began to develop after World War II. Enthusiasm today for this field is typified by Bransford, who declares, "There is little doubt that current research on human cognition has become more exciting and productive than in any previous time in history" (1979, p. vii). Stievater's 1978 bibliography of recent dissertations on creativity and problem-solving includes 113 listings.

Researchers in the 1930s studied the workings of the mind in problem-solving and creative activities, often by asking problem-solvers and creators to think aloud or to report their thoughts later. These early investigators rebelled against the tenets of behavioral psychology which held that it was impossible and unnecessary to study what went on in the human mind. An example of the "think-aloud protocol" still used today is in the work of Larkin (1979) which describes beginner, intermediate, and professional levels of problem-solving in physics.

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Both problem-solving and creativity studies began to take on separate intellectual dimensions in the 1950s. Bloom and Broder (1950) studied the problem-solving abilities of college students using methodologies developed by introspectionist psychologists. In their "exploratory investigation," Bloom and Broder acknowledged that techniques to study problem-solving, systems to represent the processes, and criteria to insure adequacy of sampling of problems had to be perfected before research in this field could be greatly improved or stabilized. Later research has in fact accepted this challenge, as evidenced by the methodological gains of Bransford (1979), Perkins (1981), and Hunt (1982).

If the work of Bloom and Broder can be thought of as a starting point for the modern study of problem-solving, J. P. Guilford's presidential address to the American Psychological Association in 1950 is considered the stimulus for the modern study of creativity. Again, there are earlier roots; the work of Wallas (1926), for instance, laid down a four-phase organizational model for creative thinking: preparation, incubation, illumination, and verification. Various investigators have modified Wallas's model over the years. Stein (1974) developed an approach that describes the creative process as hypothesis formation, hypothesis testing, and communication of results. Stein's model, in adding communication of results as a step in the creative process, allows creativity to be viewed as a *social* process in which intermediaries play significant roles. For example, art critics, gallery owners, and museum staff may play key roles in bringing a painter's work to public attention.

Although separate roots can be traced for the study of problem-solving and creativity, a relatively new technology bridges the two activities: heuristics—rules of thumb that are helpful to thinking, but do not guarantee results. Examples of heuristics include deliberately thinking metaphorically, exploring a large number of alternatives, and analyzing situations systematically (Perkins 1981, p. 192).

Applications in higher education. In reviewing the literature that describes the teaching of these processes, one finds one of three purposes for either effort. First, this is an effective methodology to teach students a specified *subject*. A second is to teach *generally useful skills*. In the field of problem-solving, Meeth (1978) called this "teaching people to reason as independent learners" (p. 148). A third is related to the second in that both view problem-solving and creativity as an end rather than a means; however, it aims to teach *specific skills* useful to a professional field of endeavor, e.g. diagnosing medical problems in medical school. Meeth called this "understanding a discipline as it is perceived and practiced by professionals" (1978, p. 148).

The first course goals (teaching a subject and teaching generally useful skills) are related in that such programs often focus on teaching a process, i.e., teaching the *steps* of solving problems or thinking creatively. On the other hand, the third purpose (teaching professional skills) often focuses on the product, i.e., students learning to solve problems or be more creative by building a repertoire of many problem-solving and creative experiences.

Problem-Solving

Learning a subject. Black (1971) describes an engineering course at the University of Alabama for non-engineers. The primary objective of this course was to enable nonengineering students to understand better the impact of engineering on their lives. Although the major method of teaching was lecturing by the instructor, the theme was the historic role of engineers in trying to solve problems of society. For their term projects, students defined a contemporary problem, collected facts, and reached conclusions. Black's experience suggests that problem-solving as a methodological approach may attract students to a new subject. A program at SUNY-Stony Brook introducing students to the characteristics, capabilities, and limitations of a technological environment is described by Truxal (1980).

Another approach known as "guided design" was developed by Wales and Stager (1977) for engineering students. In it the instructor formulates a problem that requires students to state a problem objective; list constraints, assumptions, and facts; generate possible solutions; choose a likely solution; analyze and evaluate the solution; and report the results. A key feature is providing students feedback at each step. The guided design method has been applied to a wide variety of arts and science courses (Tate 1980, p. 14). According to Martinson, who used guided design to teach Latin American geography, "When all the instruction and feedback steps are completed, the students have studied, discussed, and learned as much geography as they would in a traditional class, or more" (Martinson 1981, p. 7). Although Scheinberg (1979) has demonstrated that geography students in a guided design course scored higher on a test of critical-thinking abilities (the Watson-Glaser Critical Thinking Appraisal) than a control group in a traditional geography course, it is not known if they learned more geography.

In another course intended to use problem-solving as a way to teach the subject, Baldwin et al. (1975) describe master's degree program in environmental science at Miami (Ohio) University which provides students with an algorithmic process for dealing with problems. The use of a problem-solving framework is seen as necessary in order that the various participating disciplines constituting environmental science can be brought together without overlapping. Students use 10 steps to solve the problem presented to them: goal setting, translation of goals into objectives, data collection, data analysis, generation of alternate solutions, forecasting of the outcome of solutions, evaluation of the alternate solutions, selection of the best solution generated, implementation of the selected solution, and inspection of the implementation process. As with the guided design approach, it is unclear as to whether this approach increases the learning of a subject over traditional approaches. However, proponents believe that much information is learned and understanding gained when students follow the series of steps which lead to a solution. More importantly, they believe that a coherent stepwise process assures a more wholistic approach to solving a problem.

Teaching generally useful skills. This approach foc-

uses on a set of strategies and heuristics rather than on a series of specific steps to be followed. Programs attempt to help students become better thinkers. For example, at the University of Nebraska, faculty have created the ADAPT program to help students develop abstract reasoning skills. Students who enroll in the program take courses in traditional subjects during the freshman year, but instructors make use of problem-solving teaching methods, borrowing heavily from the cognitive development theories of Piaget. Here content learning is secondary to reasoning skill development (Fuller, 1977).

The University of Massachusetts, Xavier University in New Orleans, Whitter College, and Bloomfield College of New Jersey also report the implementation of programs that aim to teach problem-solving as a generally useful skill (Whimbey, 1980). Based on the experience of these programs, Whimbey concludes that the basic lesson teachers can impart to students is simply to be extremely thorough and careful in their thinking (1980, p. 565). He advocates the reiteration to students that the core of academic success is systematic, accurate thought.

Vye and Bransford (1981), in comparing "thinking-skills" programs developed by Whimbey and Lochhead, Fuerstein, and Lipman et al., found that these programs emphasize the importance of making *explicit* those thought processes which usually are implicit. Students are encouraged to think aloud or to analyze their strategies for solving various problems. While encouraged by the potential of these programs, Vye and Bransford point to the need, unmet so far, to study whether, under controlled conditions, a matched group of students in a thinking-skills course would outperform a group not enrolled in such a course.

The evaluation issue is being addressed by Woods et al. (1979) who describe the start of a fifteen-year project at McMaster University to develop a problem-solving program for engineering students, To evaluate the results, they plan to develop and validate technical problems rather than use existing critical instruments (such as the Watson-Glaser test used by Scheinberg) to compare students. As a result of their first six years of study, Woods et al. identified general challenges in the teaching of problem-solving, including: to introduce problem-solving as a subject in its own right; to increase a problem-solver's awareness of his or her process; and to identify and introduce students to an organized approach (or strategy) for solving problems and eventually to help individuals develop their own strategy (1978, pp. 279-282). The evaluation of the McMaster program will help answer the thorny question of the effectiveness of problem-solving training. In particular, what needs to be evaluated is whether the teaching of strategies and heuristics helps students solve problems in the outside world.

Teaching specific skills. In the field of physics, for example, Rief and St. John describe a laboratory to teach basic skills, such as ability to estimate errors of quantities obtained from measurements, and higher level skills, such as ability to modify the design of an experiment when one is confronted with slightly different conditions (1979, pp. 950–951).

In a review of problem-solving in physics, Larkin et al. (1980) describe differences between experts and novices. By definition, experts have more knowledge than novices; however, what seems to be key to problem-solving is that experts can evoke rapidly particular information relevant to a problem at hand. According to Larkin et al. (1980, p. 1342): "The expert is not merely an unindexed compendium of facts, however. Instead, large numbers of patterns serve as an index to guide the expert in a fraction of a second to relevant parts of the knowledge store," they write.

In a study of medical problem-solving, Elstein, Shulman, and Sprafka (1978, p. 276) came to the same conclusion. "The differences between experts and weaker problem-solvers are more found in the repertory of their experiences, organized in long-term memory, than in differences in the planning and problem-solving heuristics employed," they say.

Barrows, who worked briefly with Elstein and Shulman, today is a major proponent of using a problem-based approach to medical education, and, with Tambyln, has written a basic text on the subject (1980). Barrows and Tambyln, who developed problem-based learning systems at McMaster University, argue that problem-based learning is tailor-made for medicine (1980, p. 13): "It provides advantages for both the acquisition of knowledge and the development of essential skills in patient problem-solving. Information, concepts, and skills learned by the student are put into his memory in association with a problem. This allows the information to be recalled more easily when he faces another problem in which the information is relevant," they believe.

Other examples include the work of Becknell and Smith (1975) in nursing, Silvestri (1981) in dentistry, and Altmaier in counseling (1981). In general, these programs focus on the product of problem-solving rather than the process. In other words, there is a focus on developing patterns of information by giving students many problems to solve. These researchers believe that as they build on a base of problem-solving experiences, students will come to see similarities among types of problems.

The advice of Stonewater (1980) may be helpful in this regard. He advocates paying attention to Piaget's theories of learning, using self-paced approaches, emphasizing systematic instructional design, providing continuous feedback to students, and using group learning activities.

Creativity

In reviewing the literature on creativity, one finds a fervent belief in its importance to society. For example, Coler states, "There is probably no subject of greater importance to our future than creativity. . . ." (1966, p. 72). Hughes suggests that "the dominant idea of our period in history is creativity" (1969, p. 74).

As with problem-solving, efforts to teach creativity include use as a means—to teach a subject—and as an end—to teach either generally useful or specific skills. The distinction between process and product is particularly important in understanding creativity. Some investigators, including Whiting (1958) and Stein (1974) have emphasized the process of creativ-

ity where others, such as Coler (1966), have been concerned with the creative products that result.

Learning a subject. Brown and McFarlin describe a combination of learning theories and teaching techniques they used to optimize creative learning and discovery experiences in an introductory history class "the contemporary world in historical perspective." They presented a multi-side approach using books, films, and debates to explore the issue of the dropping of an atomic bomb on Hiroshima. At the end of the course, students were asked to write a personal essay, describing, if possible, an "eureka" experience they had in the course. The instructors judged one-third of the essays to be "highly original, sensitive, thoughtful, and well-argued" (1980).

Teaching useful skills. The need to teach creativty as a generally useful tool is discussed by Hooper, who was concerned with the apparent inability of students in a graduate seminar to "free their minds of the present reality and to reach out into the realm of new ideas" (1977, p. 287). She determined that creative thought should be one of the major objectives of higher education. In recent years, numerous college teachers have attempted to stimulate creativity in students. These proponents include both scientists and artists. For example, Hughes (1969) describes the role of studying science to help non-science majors learn creativity, at the most, and persistence, at the least. On the other hand, Mahoney (1973) describes a program developed by Lash at the University of Northern Iowa which uses art to teach non-artists to discover the creative process, extend their own physical senses, and appreciate human achievement.

As mentioned earlier, many researchers see problem-solving and creativity as processes of human cognition, with the caveat that some also see non-cognitive, attitudinal dimensions in creativity. Because problem-solving and creativity are related, often there is an attempt to teach these as an interrelated process. For example, Sparks (1972) describes a course for freshmen at Case Western Reserve, "inventive reasoning," which offers students a set of experiences in looking at problems through the eyes of an inventor. In this course, there is an attempt to develop enthusiasm for problem-solving and creative thinking.

Usually, programs teaching creativity as a generally useful tool use heuristics: for example, asking students to think like an inventor or encouraging them to reach a high level of abstract reasoning. Arnold (1956) would ask students at MIT to design a variety of products for use by inhabitants of an imaginary planet. Guiding students to think of far-fetched solutions is another heuristic. By thinking of improbable answers, students break through habits of thinking that limit creativity. Formulating as many solutions as possible is the essential mechanism of brainstorming, a technique developed by Osborn (1963) which encourages members in a group to generate many ideas before evaluating them. An additional heuristic developed by Gordon (1961), known as synectics, encourages users to think in terms of analogies.

Teaching specific skills. Such programs are found in both the sciences and the arts because most educators believe that creative thought is a necessary trait of both the scientist and the artist. In addition to using heuristics similar to those used to teach generally useful skills, instructors' efforts to teach creativity as a specific skill emphasize cultivation of the environment for students who already are "creative." For example, Myron Coler, former director of the creative science program at New York University, states that when working with creative students, "the odds are in favor of any reasonable teaching environment" (1966, p. 76). Similarly, Vittorio Giannini, first president of the North Carolina School of the Arts, states that "Creativity can be best nurtured by competent, sensitive teachers and through living and associating with students of similar interests" (1968, p. 76).

Upon review, one finds that programs which aim to teach creativity for a field of professional endeavor are less explicit than the general-skills programs. In a professional field of either the arts or sciences, one could imagine how superfluous a "creativity course" would sound to students. Instead, skill-specific programs, such as music composition or industrial research design, focus on creative products rather than on a creative process. In other words, there is an emphasis on providing students opportunities to build up scientific or artistic experiences.

The possibility that students can be taught to be better problem-solvers or to be more creative is exciting to us in the teaching profession. Opinion is mixed as to whether it can really be done. With regard to problem-solving, one journalist reports, "Some say yes, some strongly doubt it, and the majority opinion among cognitive scientists was voiced (at a recent conference) by Jill Larkin, who said somewhat plaintively, 'It just seems to be very hard to teach people to solve problems'" (Hunt, 1982, p. 266).

Unquestionably, problem-solving as a *means* to teach a subject encourages active learning more than lecturing. Proponents believe that, even if students do not learn more content with problem-solving approaches, what they do learn is better remembered and used in the future. With problem-solving as an *end,* the key question is whether it can be taught as a general skill that can be transfered into daily life. At this point, there is no consensus (Hunt, 1982).

According to Bogue (1981), one obstacle to the use of problem-solving techniques is that theorists who conduct investigations do not do so with the educator in mind. In order to create problem-solving programs using the findings of research, she recommends that those conducting the research and reporting the results adopt a standard set of definitions.

Sadler and Whimbey (1979), based on the experience of the cognitive-skills approach at Bloomfield College, warn that, even when research is improved, problem-solving programs may be faced with "premature extinction" unless institutions extend the problem-solving approach beyond merely a few courses or even a core program. They recommend a broad institutional framework for promoting the teaching of problem-solving skills.

On the other hand, there does seem to be agreement that students' collection of a repertoire of experiences fosters problem-solving and creative work, due largely, researchers believe, to the patterns of information they learn over time. Ironically, a focus on

products may be more effective than emphasis on a process in learning a subject. Yet many programs which aim to use problem-solving and creativity as a means to teach a subject emphasize a process. Thus, rather than using a process in prescribed detail to solve one problem or create one project over an academic term, instructors might find that students learn more subject matter when they are exposed to solving many problems and creating many works.

Using creativity as a means to teach a subject is more stimulating than straight lecturing. Again, it is difficult to document increased learning of subject matter. However, it seems plausible that students retain more with this method of instruction. With creativity as an end, evaluation studies seem to support the view that "creativity test" scores can be increased; however, how much of it students transfer into daily life is unknown. Thus, the field of development and evaluation of programs remains open to experimentation. Stein (1975) suggests that future research efforts should test the relative value of different techniques for stimulating creativity and that researchers should provide evidence as to the procedures their subjects actually use. In addition, he believes that researchers should use problems to test for creativity for which a correlation with creative behavior has already been demonstrated.

The possibilities, as expressed by Perkins, are inviting: ". . . [creative abilities] can be understood as exceptional versions of familiar mental operations such as remembering, understanding, and recognizing. They are more of the same. Creativity has to be understood as the combination of traits which fosters the creative use of that *more*—the mind's best work" (1981, p. 274).

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ERIC accepts proposals for 1983–1984 Research Currents

The ERIC Clearinghouse on Higher Education is accepting proposals for "Research Currents" to be published in 1983-84 issues of *AAHE Bulletin*. "Currents" are reviews of the literature on a specific topic of concern to a broad audience within higher education. Articles are 3,000 to 3,500 words in length, including a bibliography of up to 40 entries. ERIC and AAHE will review proposals on the basis of the appropriateness of the topic, evidence of thorough scholarship, and writing style. ERIC will supply authors with computer searches of two bibliographic journals, *Resources in Education* and *Current Index to Journals in Education*.

In addition to publication in an issue of *AAHE Bulletin*, "Currents" articles are made available through ERIC/Higher Education, the AAHE Publications Department, and on microfilm.

Submit a 200-word description of your planned article, along with a vita and writing samples, to Jonathan Fife, director, ERIC Clearinghouse on Higher Education, One Dupont Circle, Suite 630, Washington, D.C. 20036.

News & Information

Nominees selected for spring election to AAHE Board

Members will elect by mail ballot three persons to AAHE's Board of Directors this spring. (Two additional members will be appointed by the Board itself). Due to the death last year of chair-elect Stephen Bailey, two of the three positions lead to service as chair of the Board.

This year's nominating committee, which reviewed and selected the candidates listed below, was chaired by David Brown, past chair and president of Transylvania University. Also serving on the committee were Laura Bornholdt, vice-president of the Lilly Endowment, and David Breneman, senior fellow, Brookings Institution.

According to AAHE by-laws, additional candidates may be nominated by petition. These must be submitted by midnight, March 28, 1983. Two hundred member signatures are needed to nominate a candidate for the position of vice-chair and/or chair-elect. One hundred member signatures are needed to nominate a candidate for the other position.

Nominees for vice-chair (to become chair in 1985):

Robert McCabe, president, Miami Dade Community College
William Nelsen, president, Augustana College (S.D.)
Harriet Sheridan, dean of the college, Brown University

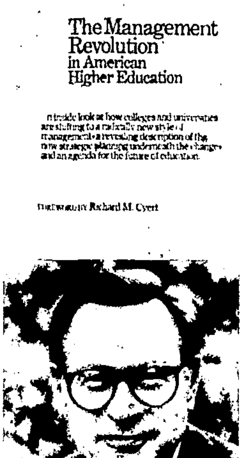
Nominees for chair-elect (to become chair in 1984):

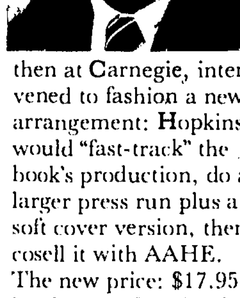
Frank Newman, president, University of Rhode Island
Gloria Scott, vice-president, Clark College (Ga.)
Helen Astin, professor of higher education, UCLA

Nominees for regular position:

Eva Hooker, CSC, associate dean of the faculty, Saint Mary's College (Ind.)
Estus Smith, vice-president for academic affairs, Jackson State University
Arthur Levine, president, Bradford College

Hopkins, AAHE, Carnegie combine to publish Keller's *Academic Strategy*





An innovative arrangement—copublication by a leading university press and an educational association—will soon bring the education community low-cost copies of George Keller's *Academic Strategy: The Management Revolution in American Higher Education.*

The Johns Hopkins University Press and AAHE, thanks to a $14,900 grant from the Carnegie Corporation of New York, will release the book on March 28, at AAHE's National Conference.

Many people were aware that Carnegie put Keller on the road last spring and summer to find out how more imaginative universities and colleges were responding to today's exigencies. Fugitive copies of the resulting manuscript have circulated since fall. Readers find the book "intensely interesting," "practical," and "the definitive statement on collegiate strategic planning."

Keller's book had been before a major New York publisher, which planned a release next winter, in hard cover only.

People at AAHE, then at Carnegie, intervened to fashion a new arrangement: Hopkins would "fast-track" the book's production, do a larger press run plus a soft cover version, then cosell it with AAHE. The new price: $17.95 hard cover, $8.95 soft.

AAHE members will shortly receive a letter describing how to get a prepublication copy at a special price. Keller, a senior vice-president of the Barton-Gillet Company, will give a workshop and presentation at the National Conference.